Le réseau
de transport
d'électricité

RTE
And the Storage of Energy

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More than 30 years in Technical and management positions in Energy

Energy Storage

Founder and Chair of Technical Club Storage and New Generation Plant since 2016

Elected member Governing Board de EASE
Rep Rte to GA

European Expert

Independant administrator

High level expertise

Founder of Rte « Collège des émérites »

Scientific associations

Chair France Section (2020-2022)
France Section ExCom Member (2023-)
Region 8 Ad'hoc Committee Chair
European Public Policy Committee Expert – WG Energy

Member of the ExCom

Diversity

Founder of the French Women In Energy network

Rep Rte in South Asia Women In Power Sector professional Network (WB – ADB)

POWER GENERATION

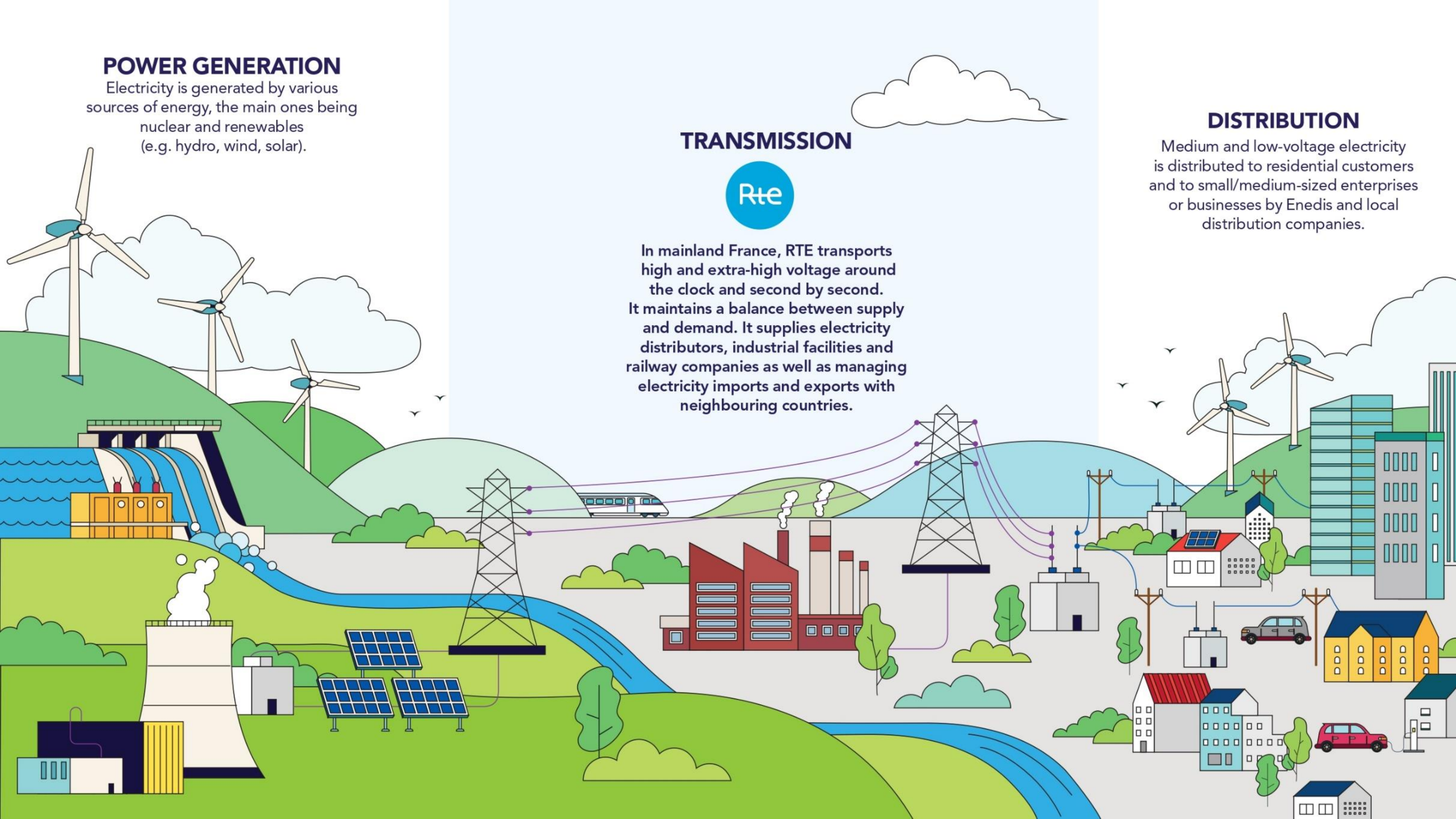
Electricity is generated by various sources of energy, the main ones being nuclear and renewables (e.g. hydro, wind, solar).

TRANSMISSION

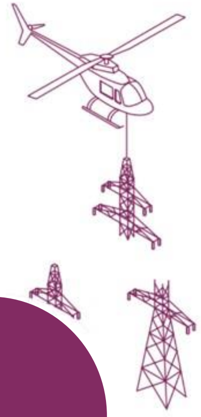
In mainland France, RTE transports high and extra-high voltage around the clock and second by second. It maintains a balance between supply and demand. It supplies electricity distributors, industrial facilities and railway companies as well as managing electricity imports and exports with neighbouring countries.

DISTRIBUTION

Medium and low-voltage electricity is distributed to residential customers and to small/medium-sized enterprises or businesses by Enedis and local distribution companies.



Rte mandates



1

Infrastructure development and maintaining

2

Flow management

3

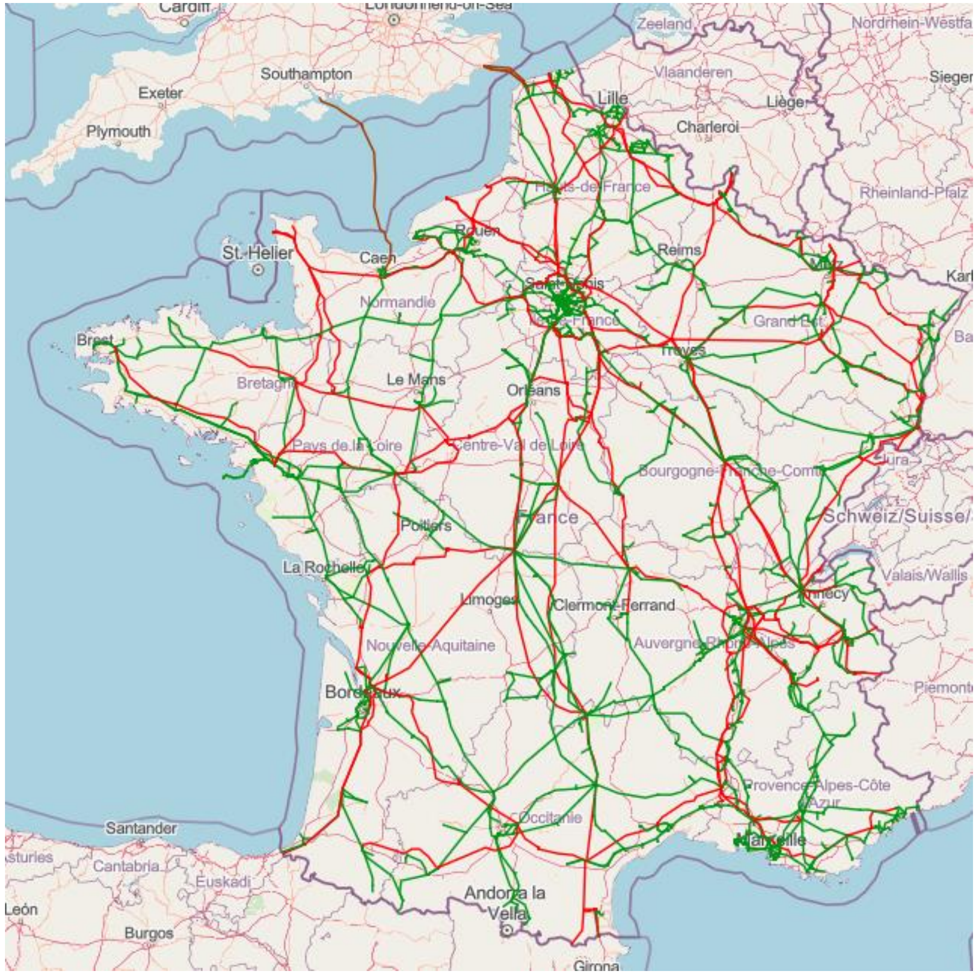
Market mecanisms design and operation

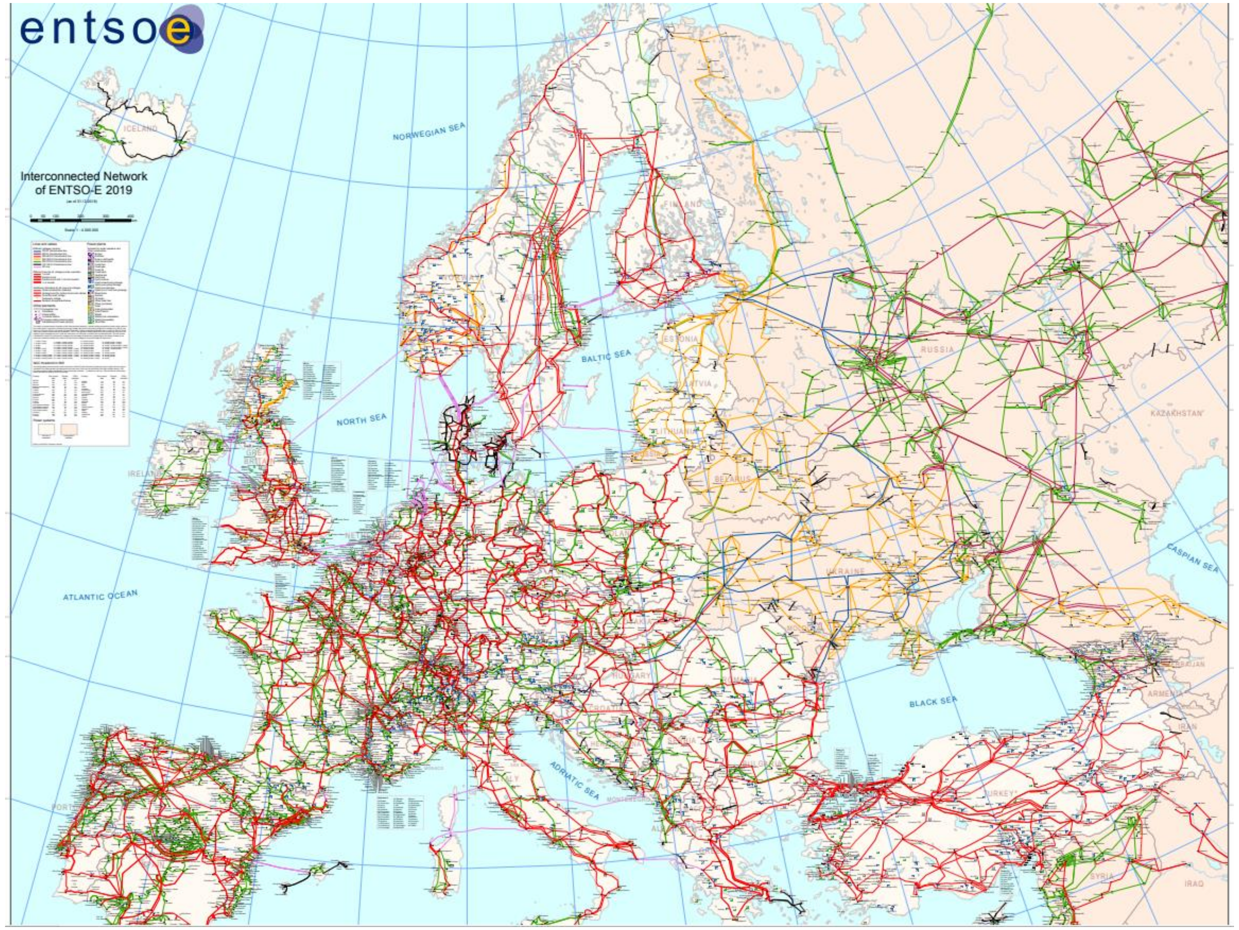
4

Research, innovation and outlook

Include all geographic scales (local, national and European) and time scales (from real time to long term ~50 to 80 y)

A strong meshed network,
connected to European grid through 51 international links





Rte and the storage

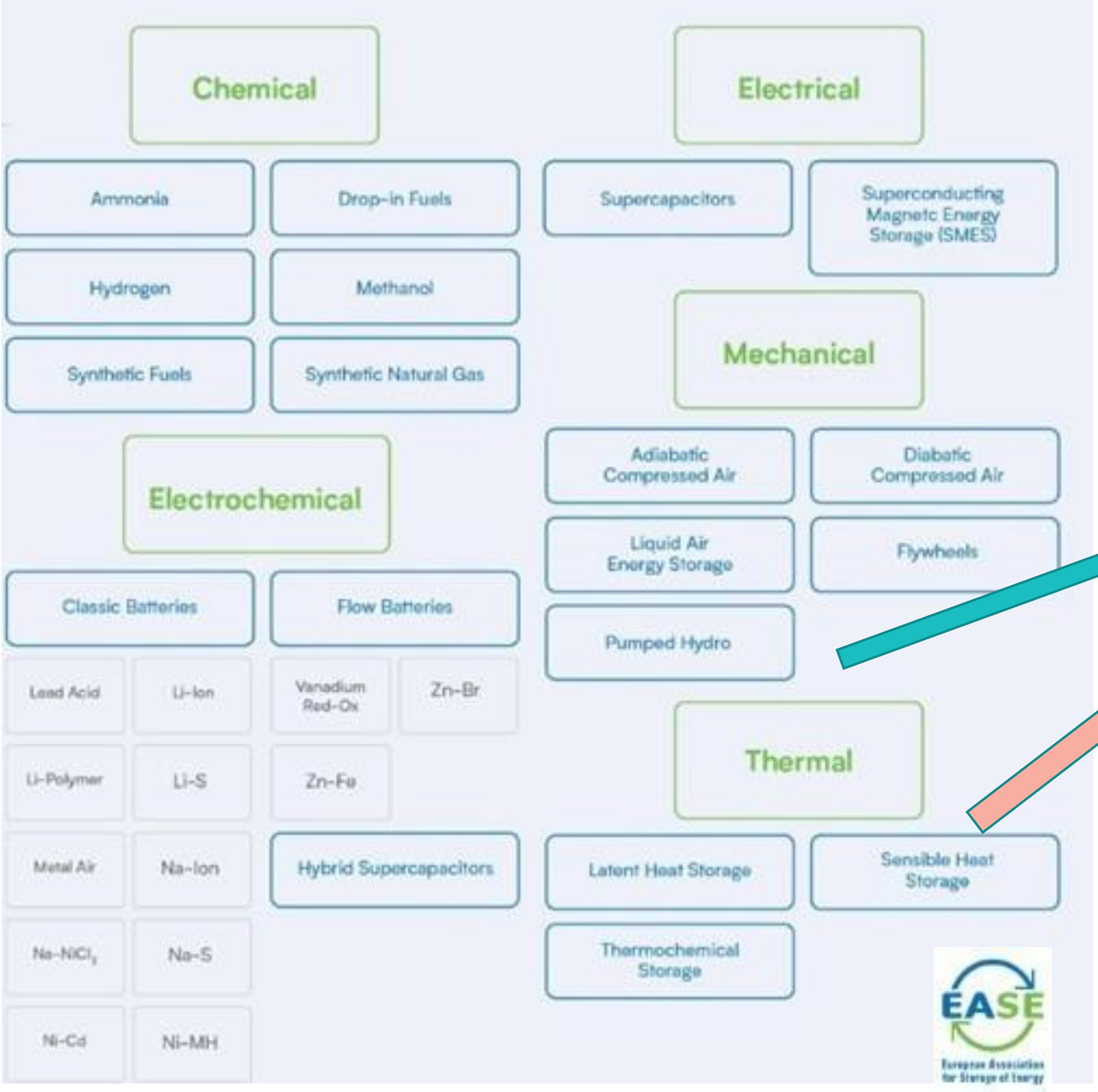
CONVERTING THE ENERGY TRANSITION INTO INDUSTRIAL POLICY

RTE sheds light on the possible options for the future of our energy.

RTE is a transmission system operator that leverages its infrastructure in support of the energy transition.

RTE maximises the efficiency of the energy transition by offering solutions to minimise the footprint of the grid and of France’s energy mix.

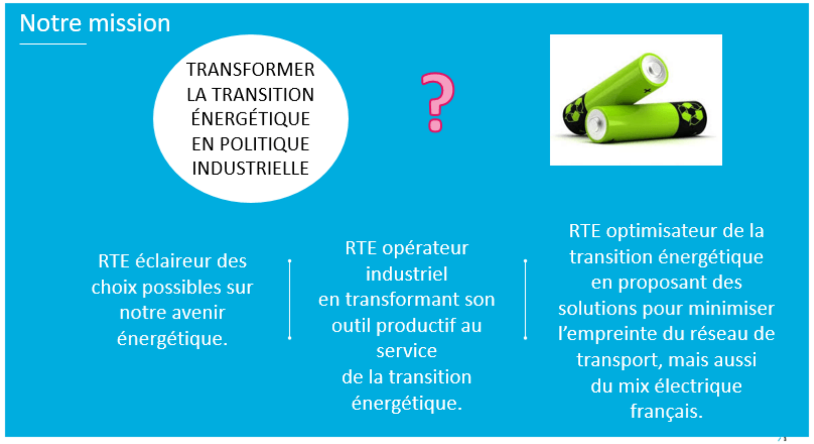
The Storage and the Grids

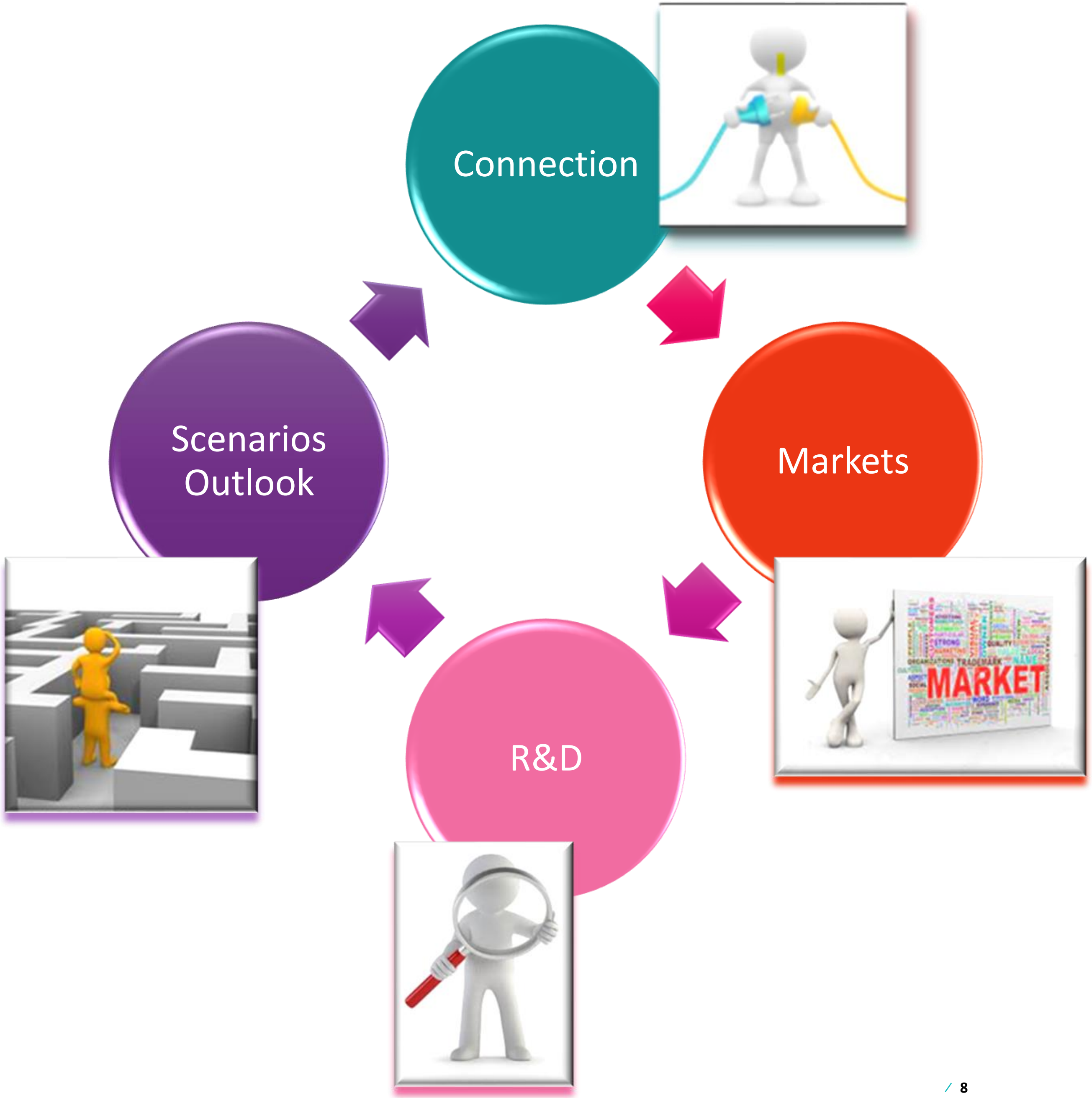


A long History :
Pumped Hydro and Domestic Heat Storage

What's new ? *Technologies allow new sites and new uses*

Rte and the storage

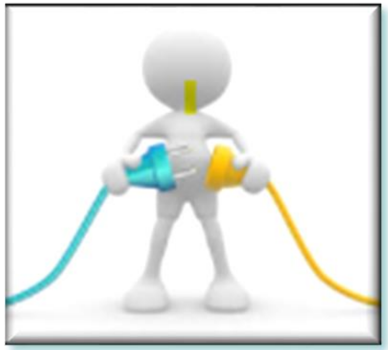




Distinct roles linked to the different mandates of Rte

A tricky detail : no strict correlation between connection to the Grid and access to the market !

Rte and the Storage : Connection to the Grid



Fundamentals :

Responsibility : technology neutrality

And adaptation to storage specificities

National and European works

Opportunities with new solutions

To accelerate / optimise the connection

Since 2021 strong take off for the storage on the French transmission grid

A dozen of new projects

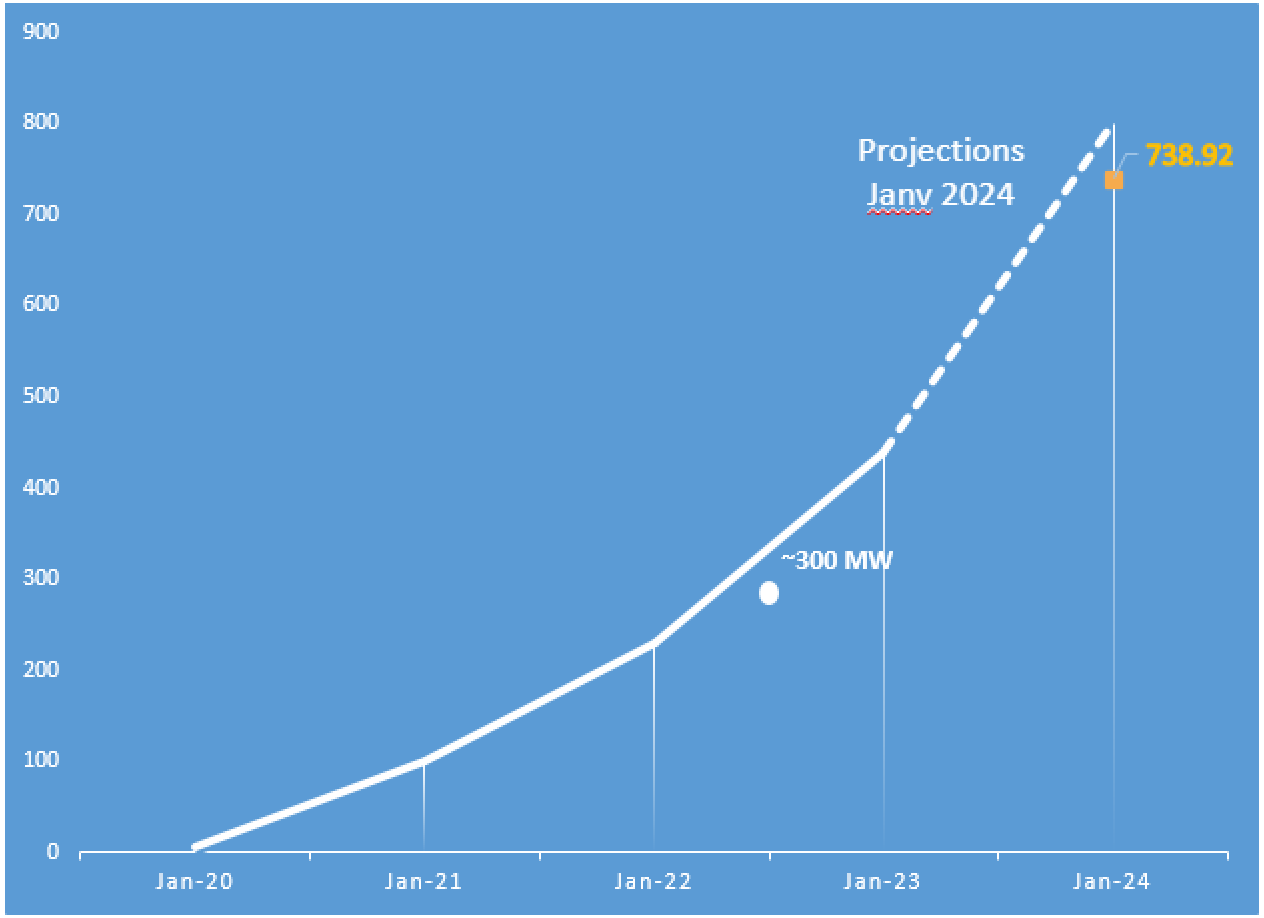
Around 500 MW

But the majority are connected to distribution grid

Où en est-on ?

	RPT	RPD	Total
Nombre de batteries certifiées	5	237	242
Puissance raccordée (MW)	119,38	318,54	437,92
RP certifiée batterie (MW)	**99**	**236,6**	**335,6**
Puissance à raccorder en projet d'ici fin 2023 (MW)	**301**	Pas de vision	**301**

Plus de 700 MW fin 2023



Rte and the Storage: Integration in the Markets

Fundamentals :

Responsibility : technology neutrality

Need for in-depth studies to adapt to specificities

Opportunity for new services

Capacity mecanism	**Call for Long Term reserve** in 2019 for low carbon technologies reserve ~250 MW BESS
Frequency Ancillary Services	**FCR (500 MW)** and **aFRR (700 MW)**
Adjustement mecanism	Specific historical frame for the PHES Intraday call for order – TERRE ENTSO-E platform
New products for news services ?	**Congestion management** – call for tender ongoing **Frequence management on the « Exact time » (xx.00) ?**

Great interest and commitment for the storage

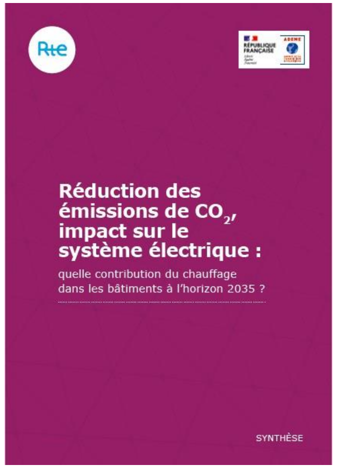
Some technical issues - Information system, multiuses, limited "small" reservoir..

Rte and the storage : integration in the Outlook

What could be the impact of storage on the scenario mix and balance ?
What would be the main issues ?

First examples :

- Impact of the Electrical mobility on the grid (2019)
- Low carbon hydrogen (2020)
- Electrical Heat



Rte and the storage : Energy Pathways to 2050

What are the possible energy pathways to reach carbon neutrality by 2050 ?

1 Technical

- Full description of the system (generation – network – consumption), in energy and power terms, in 2030, 40, 50, 60
- Projections with IPCC's RCP 4.5 and 8.5 scenarios and resiliency analysis with climate stress tests (heat wave – drought – extreme cold – absence of wind in Continental Europe)

2 Economic

- Full cost to society
- Analysis of sensitivity to different parameters, notably the cost of capital
- Specific analysis of the ability of each scenario to integrate relocation/reindustrialisation plans

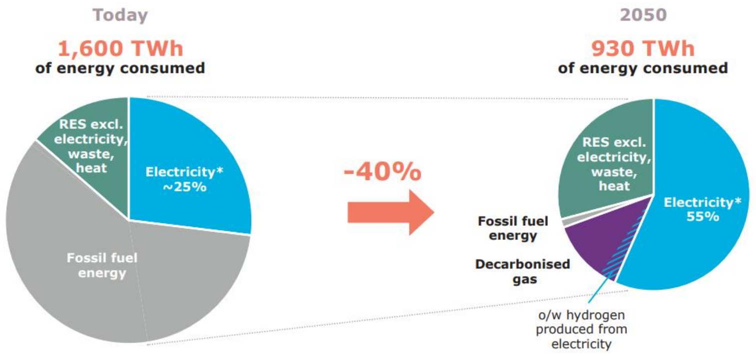
3 Environmental

- Carbon footprint at each stage of the trajectory, factoring in the lifecycle of materials
- "Materials footprint" of each scenario (in association with issues of criticality)
- Land use (network + production)
- Waste and pollutant volumes

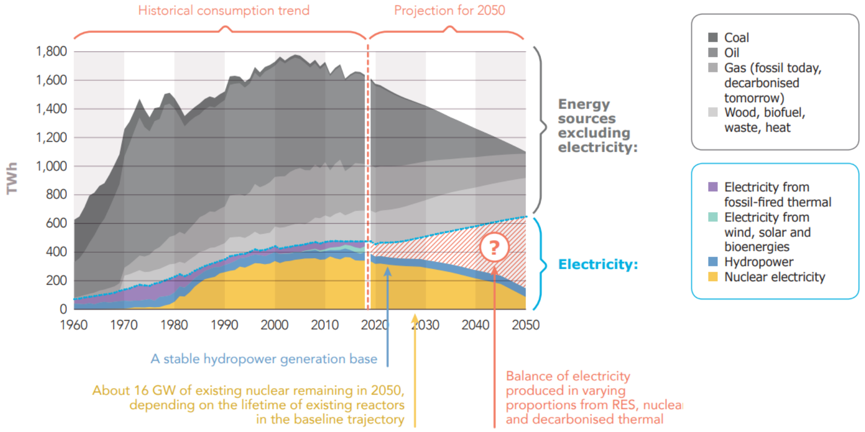
4 Societal

- Conceptualisation of impacts on lifestyles and conditions of validity of the scenarios (telework *vs.* mobility, electricity consumption, level of sufficiency desired vs. required, level of flexibility of uses)

Energy Pathways to 2050 does not take a position on the desirability of these factors



* Final electricity consumption (excluding losses, excluding consumption related to the energy sector and excl. consumption for hydrogen production)
Total electricity consumption in RTE's baseline trajectory = 645 TWh



Rte and the storage : Energy Pathways to 2050

GENERATION MIX SCENARIOS
IN 2050

Tech: Demand-side flexibility (excl. V2G) · Vehicle-to-grid · New decarbonised thermal · Batteries

	NARRATIVE	GENERATION MIX IN 2050	INSTALLED CAPACITY IN 2050 (IN GW)*: Solar	Onshore wind	Offshore wind	Historical nuclear	New nuclear	MIX OF FLEXIBLE RESOURCES IN 2050
M0 100% RES in 2050	Nuclear is phased out in 2050: the decommissioning of existing nuclear reactors is accelerated and the rate of development of solar, wind and marine energies is pushed to the maximum.	100% RSE; 9%, 21%, 31%, 36%	~208 GW (i.e. x21)	~74 GW (i.e. x4)	~62 GW	/	/	15 GW 1.7 GW (1.1 M EV) 29 GW 26 GW
M1 Distributed	Very robust development of distributed renewable generation across the country driven in large part by solar. This development implies strong mobilisation on the part of local actors and governments.	13% Nuc.; 87% RSE; 9%, 13%, 17%, 23%, 36%	~214 GW (i.e. x22)	~59 GW (i.e. x3,5)	~45 GW	16 GW	/	17 GW 1.7 GW (1.1 M EV) 20 GW 21 GW
M23 Large RES	Very robust development of all renewable technologies, driven notably by the installation of large onshore and offshore wind farms. Focus on economic optimisation and the technologies and geographic areas with the highest efficiency to allow economies of scale.	13% Nuc.; 87% RSE; 9%, 13%, 21%, 32%, 22%	~125 GW (i.e. x12)	~72 GW (i.e. x4)	~60 GW	16 GW	/	15 GW 1.7 GW (1.1 M EV) 20 GW 13 GW
N1 RES + new nuclear 1	Launch of a programme to build new nuclear reactors, developed in pairs on existing sites every five years starting in 2035. Robust development of renewables to offset the decommissioning of second-generation nuclear plants.	26% Nuc.; 74% RSE; 9%, 14%, 12%, 17%, 24%, 22%	~118 GW (i.e. x11)	~58 GW (i.e. x3,3)	~45 GW	16 GW	13 GW (i.e. 8 EPR)	15 GW 1.7 GW (1.1 M EV) 11 GW 9 GW
N2 RES + new nuclear 2	Launch of a programme calling for the faster development of new reactors (a pair every three years) from 2035 with a gradual ramp-up. Renewable energy development continues but at a slower pace than in scenarios N1 and M.	36% Nuc.; 63% RSE; 9%, 14%, 22%, 16%, 20%, 17%	~90 GW (i.e. x8,5)	~52 GW (i.e. x2,9)	~36 GW	16 GW	23 GW (i.e. 14 EPR)	15 GW 1.7 GW (1.1 M EV) 5 GW 2 GW
N03 RES + new nuclear 3	The generation mix is evenly split between renewables and nuclear in 2050. This implies keeping existing nuclear power plants in service for as long as possible and proactively developing a diversified mix of new nuclear (EPR 2 + SMR).	50% Nuc.; 50% RSE; 10%, 23%, 27%, 13%, 12%, 13%	~70 GW (i.e. x7)	~43 GW (i.e. x2,5)	~22 GW	24 GW	~27 GW (i.e. ~14 EPR + a few SMRs)	13 GW 1.7 GW (1.1 M EV) 1 GW

Overlapping assumptions	Hydropower	Marine energies	Bioenergies	Imports	PSH
	~22 GW	0 to 3 GW	~2 GW	39 GW	8 GW

*Energy quantities and shares are expressed in relation to the baseline consumption scenario.

Key finding 8 Overview of flexible capacity requirements to contribute to security of supply in 2050 (baseline consumption trajectory)

FLEXIBILITY NEEDS

Needs

- Significant flexibility needs in all scenarios, ranging between 28 GW and 68 GW
- Needs are much more pronounced in scenarios with very high renewable penetration

NEW CAPACITY NEEDS*

FLEXIBILITY LEVERS

Hydropower

- Limited development (<1 GW) of dispatchable hydropower capacity (excluding PSH), mostly resulting from the redesign of certain infrastructure
- About 3 GW of PSH developed (capacity raised from 5 to 8 GW), tapping into that technical potential

INSTALLED CAPACITY

CCGT/CT

- Very significant need for new thermal power plants under all 100% renewable scenarios, in N1 and even N2
- The plants will need to run on decarbonised gas (hydrogen, synthetic methane, biomethane)
- They will be operated for short periods on average and their use will vary widely from one year to the next, occurring mostly in winter

INSTALLED CAPACITY

Batteries

- Battery development rates will depend directly on installed solar capacity
- Trade-offs will be possible between batteries and demand management
- Batteries will be used daily (to store solar power during the day and release it in the evening/morning)

INSTALLED CAPACITY

Consumption

- Robust development of consumption flexibility thanks chiefly to (i) the development of new end-uses (electric vehicles, electrolysis) and (ii) the electrification of industrial processes
- A cautious baseline configuration, not factoring in any technological or acceptability challenges, with variants to reflect uncertainties
- An assumption common to all scenarios, excluding situations where capacity exceeds needs (N03) or the effects of self-generation development (M1)

AVERAGE POWER REDUCTION/ MODULATION POTENTIAL

Interconnections

- Robust development of interconnections has economic benefits for France and Europe, allowing flexibility resources to be pooled
- Growing interdependence between national power systems in Europe raises issues of political acceptability
- Compromise between the economic optimum (~ 45 GW) and technical and political realism
- Different variants to reflect uncertainties

IMPORT CAPACITY

* Flexibility needs are expressed in "perfect" GW (always fully available with no activation constraints)

Needs and levers for all time scales !

From intra Day to interannual

Figure 7.7 Principes méthodologiques d'évaluation des besoins de modulation sur les différents horizons temporels

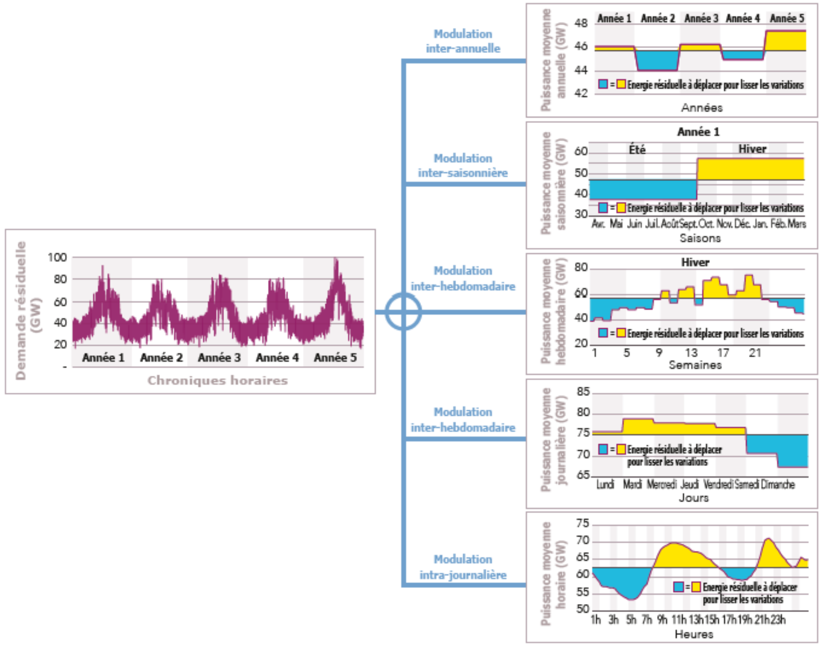
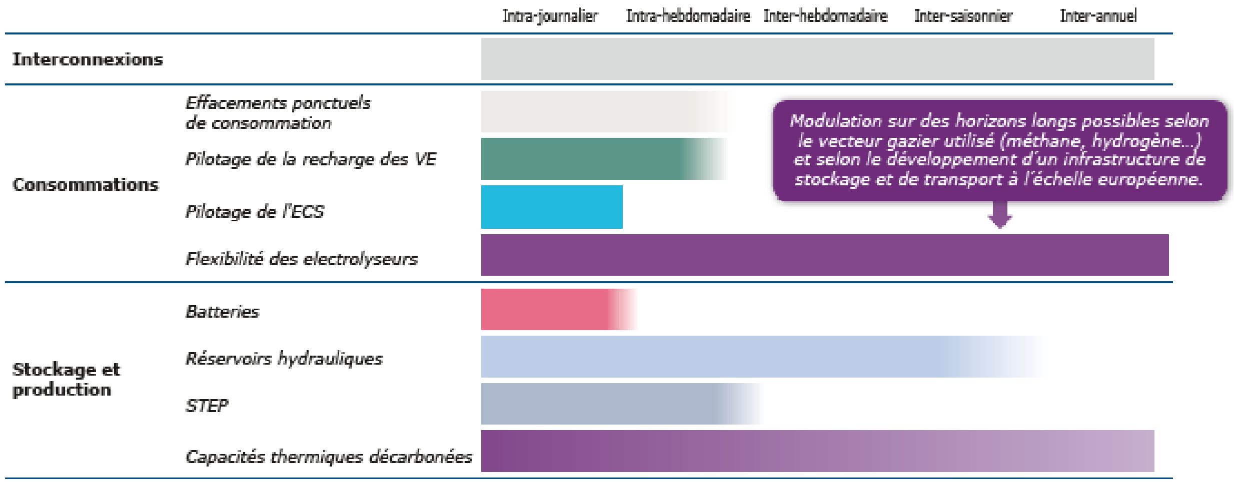


Figure 7.9 Liste des flexibililtés et de leurs échelles temporelles



And real time ! *- 30s to 1h*

Source Rte – Futurs énergétiques – oct21

Very mix-sensitive

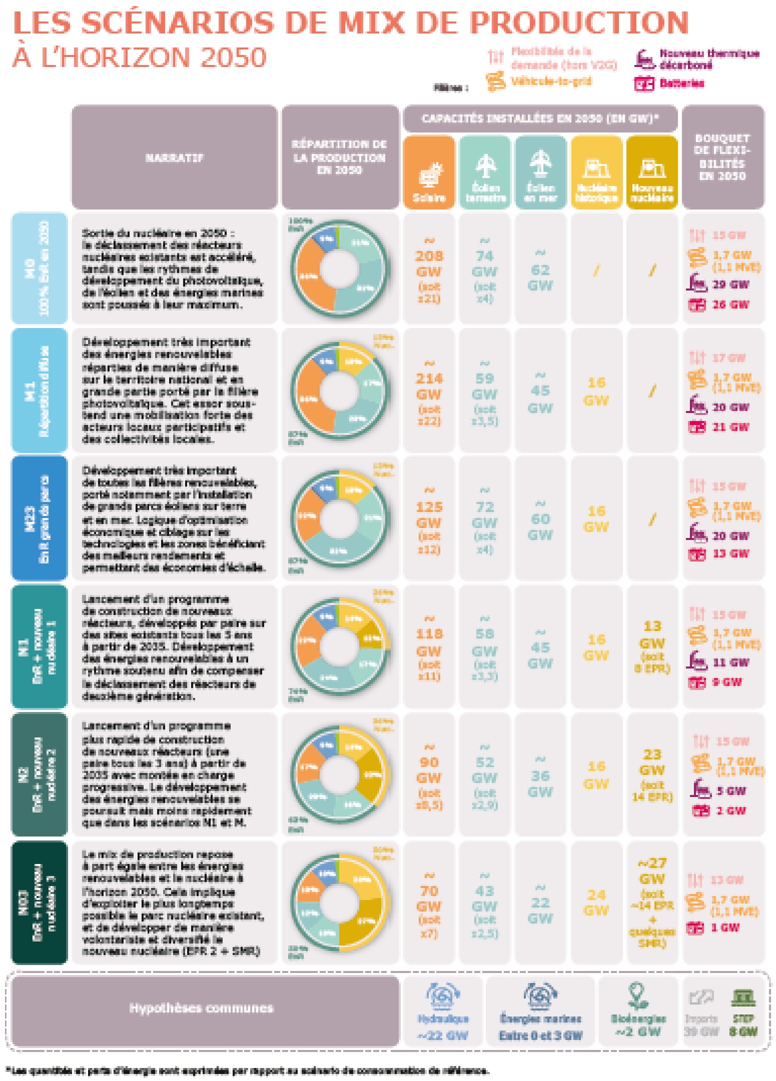
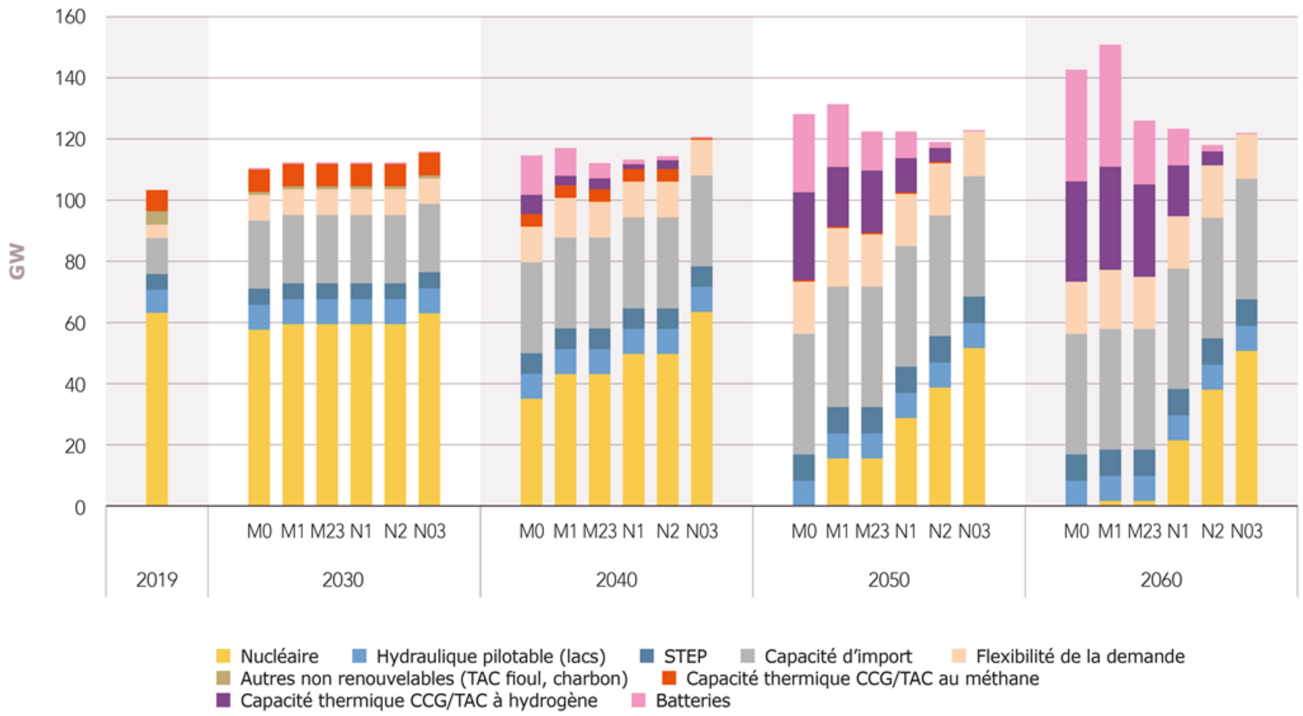


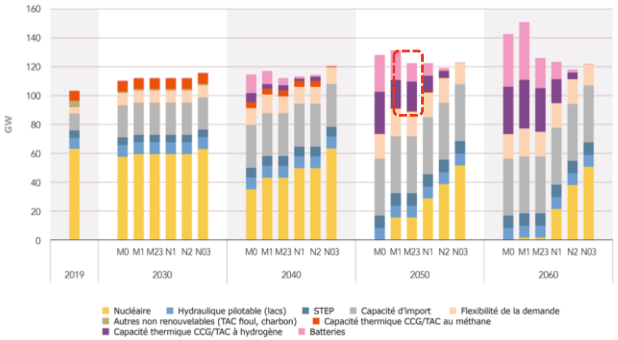
Figure 7.37 Capacités flexibles installées en France dans les différents scénarios pour assurer la sécurité d'approvisionnement[29,30]



From 26-13GW if no-nuclear (scenarios Mx) to 9-1GW according to nuclear share (26 et 50%) – some GW more likely

And very cost-sensitive

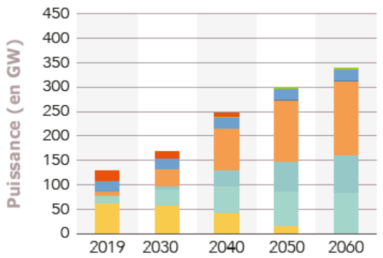
Figure 7.37 Capacités flexibles installées en France dans les différents scénarios pour assurer la sécurité d'approvisionnement[29,30]



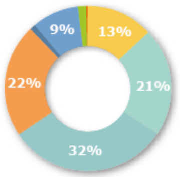
Scénario M23 : EnR grands parcs

Sources de production d'électricité

Capacités installées par filière



Bilan énergétique annuel en 2050

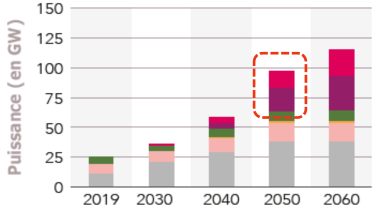


(capacité installée/production)

Filière	2050
Nucléaire existant	16 GW / 91 TWh
Nouveau nucléaire	-
Éolien terrestre	72 GW / 145 TWh
Éolien en mer	60 GW / 215 TWh
Photovoltaïque	125 GW / 153 TWh
Énergies marines	3 GW / 9 TWh
Hydraulique (hors STEP)	22 GW / 62 TWh
Bioénergies	2 GW / 12 TWh
Thermique existant*	0,5 GW / 0,5 TWh

Moyens de flexibilité

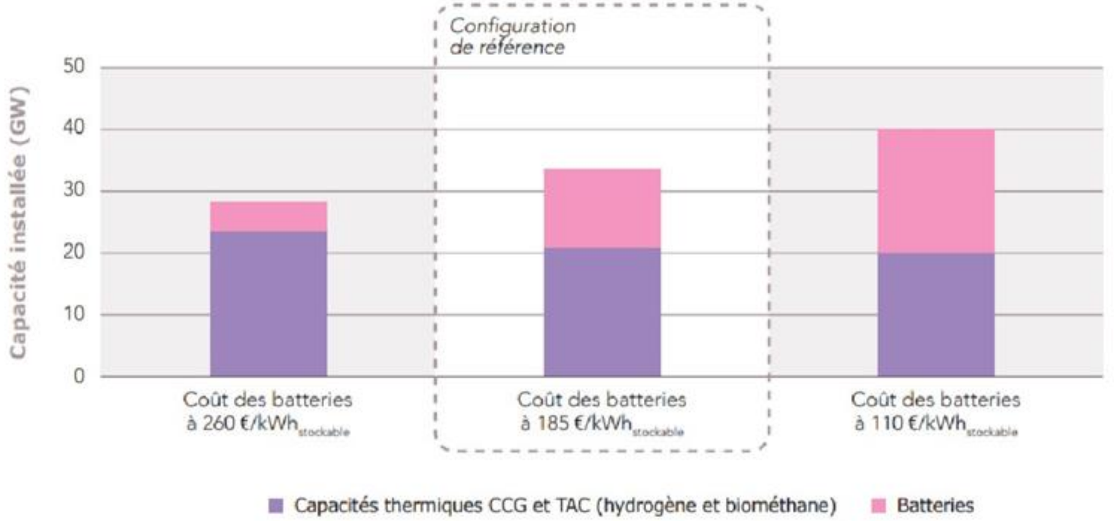
Capacités installées par filière



(capacités installées ou puissances moyennes disponibles)

Filière	2050
Capacité d'import (interconnexions)	39 GW
Flexibilités de la demande (hors V2G)	15 GW
Vehicle-to-grid	1,7 GW (1,1 million, soit 3% du parc total de VE)
STEP	8 GW
Nouveau thermique décarboné	20 GW
Batteries	13 GW

* Le combustible des moyens thermiques existants est d'origine fossile en 2021. Il est amené à évoluer pour être exclusivement décarboné en 2050.



BESS cost impact for M23 scenario

As there are different possible options, optimum will be based on their respective costs

Rte and the Storage :

Imagine and test new services :

How the storage can help to build / operate a more virtuous and efficient electrical system ?

When the storage is a virtuous flexibility lever ?

Examples :

- ***Automatic Congestion management : RINGO***
  new zonal automatism with BESS
- **Grid Forming : OSMOSE** *(European Funded project H2020)*
  new algorithm to control and command converters with storage
- **Life Cycle Analysis of BESS**
  What are the environmental footprint of a BESS ? How to reduce it ?
- **Environmental Footprint of « V2G » :**
  for different technologies
- Readiness of market VE to V2G and constraints…

Testing news solutions : case of grid congestion

The RINGO Project :

How to prevent and manage automatically congestions ?
How to integrate batteries into the Transmission Network ?

- ***3 sites selected from an multi-criteria analyses :***
  solicitation rate from number and types of congestions
  economic evaluation
  technical feasibility of the remote controller
  feasibility and constraints for the installation, ..

- ***CRE – French regulator – authorisation** (dec 2017) :*
  balance of the energy – non market disturbance
  3 years experiment then brought to the market
  call for tender for a new flexibility service
  publication of residual congestion map

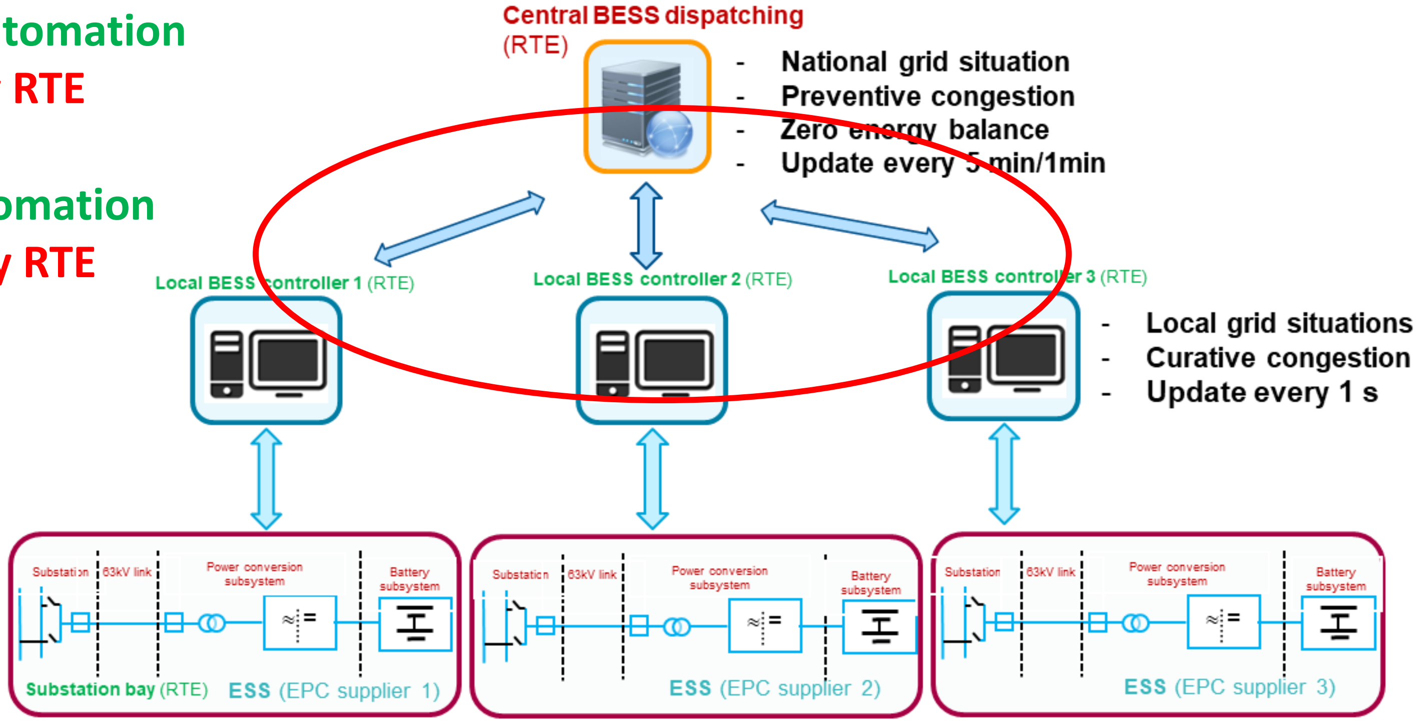
Ventavon substation 63kV: 10 MW, 2 hours

RINGO Project : what's innovative ?

EU patent
for the automatic congestion management based on a 2-levels automation

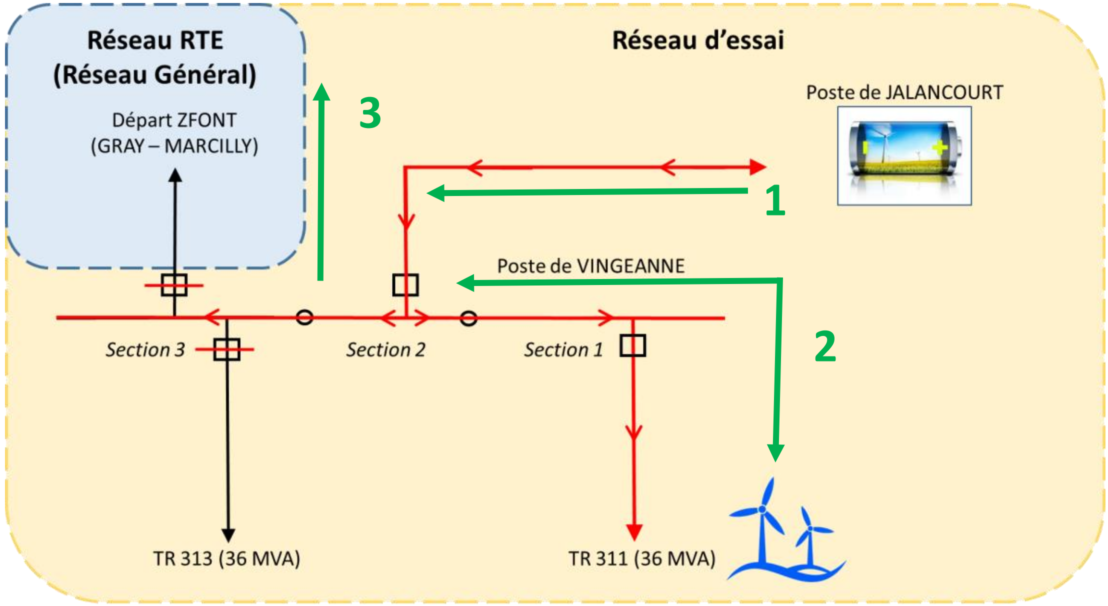
Central Automation
-> NEW by RTE

Local Automation
-> NEW by RTE



RINGO Project : an opportunistic and successful Black Start test

The test has been done par RTE through collaboration with ENEDIS (DSO), Compagnie Nationale du Rhone (owner of the wind farm) and Nidec (BESS provider).



Black Start in a 3 steps Test

1: Energization through soft voltage ramp up)
2: Wind turbines connected one by one ; 2 hours of stable operation with wind farm charging the battery,
3: Connection to the main transmission grid ; the battery switched back to grid following mode.

Main isolated grid components:
36 MVA Transformer 63kV/20kV
About 15km of 20 kV cable,
5 wind turbines

More than 25 people involved

Need for preparation based on simulation

EMTP detailed models : detection and solution of an instability control issue

Successful test :

7 hours of stable islanded operation
> 2 MW direct BESS charge from WF
successful connection to the main grid

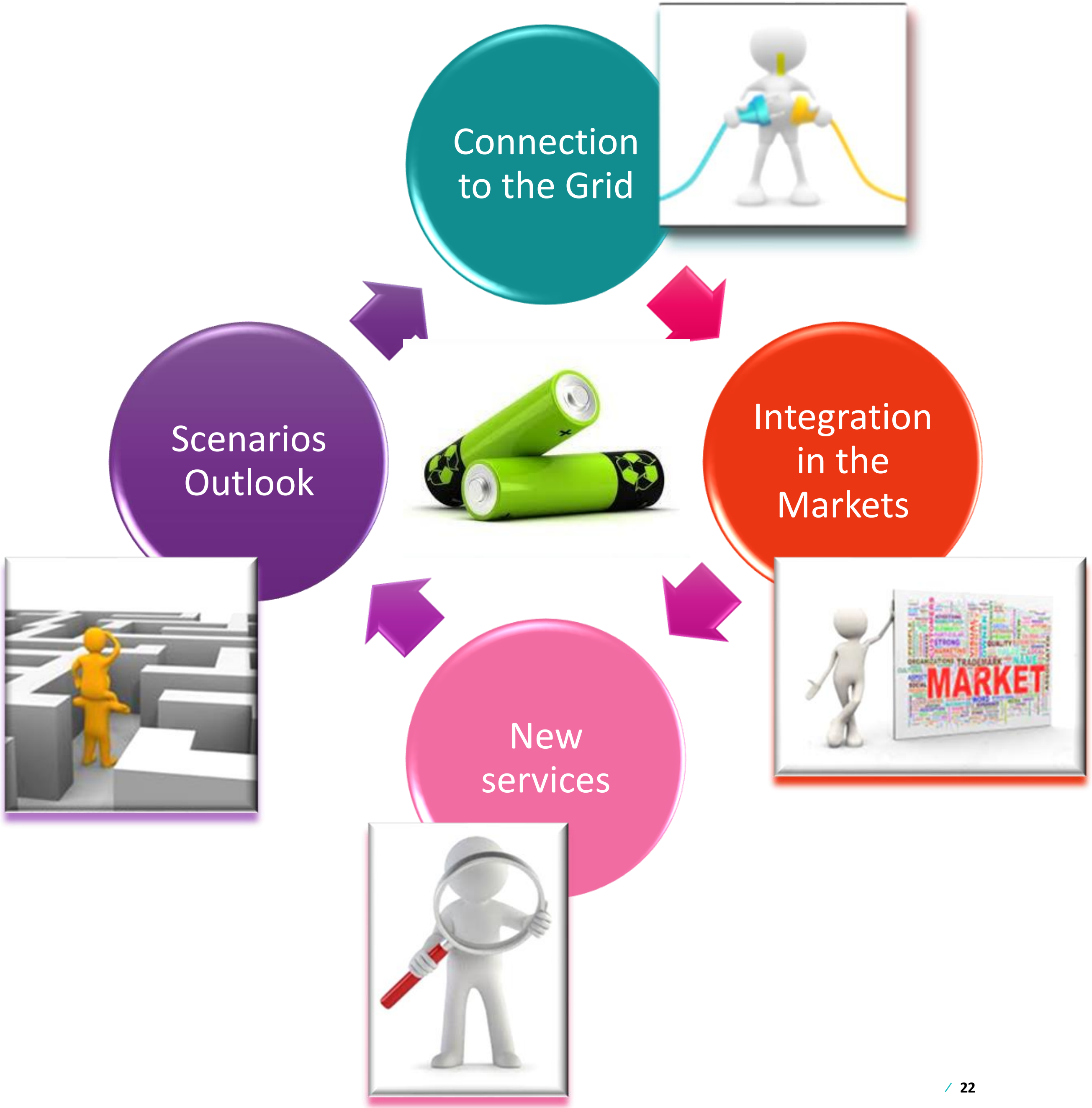
Rte and the storage

Distinct and complementary roles

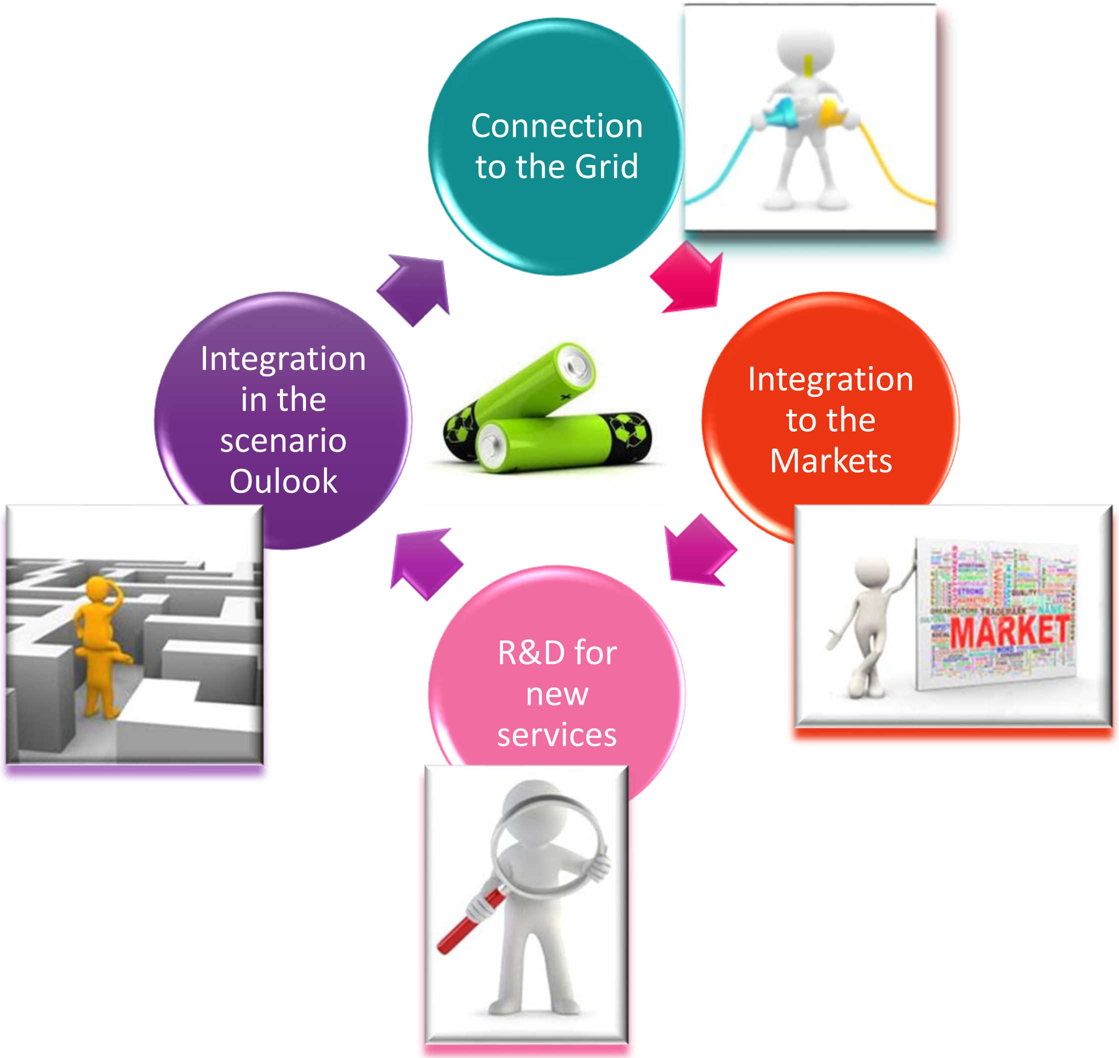
Technical Neutrality by law

R&D for new services and assess the impact to determine the best solutions

Take the best part of these new technologies for a quick and successful Energy Transition



Rte and the Storage



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Thank You